ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 11, November 2014

Proximity Coupled Equilateral Triangular Microstrip Antenna with Diamond Shape Slot for Dual Band Operation

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ABSTRACT: In this paper a design of proximity coupled equilateral triangular microstrip antenna with diamond shape slot on the radiating patch is studied. The antenna consists of two layers with glass epoxy material of thickness (h) 0.32cm each forming total thickness of 0.64cm. The proposed diamond shape slot loaded antenna resonates at two different frequencies 2.95GHz and 5.91GHz with bandwidth of 8.87% and 11.05% respectively with compared to that of conventional microstrip antenna which resonates at 3.07GHz with bandwidth of 9.15%. These antennas are simulated by using Ansoft HFSS electromagnetic simulation software. The antenna parameters such as return loss, bandwidth and radiation pattern are discussed and presented.

KEYWORDS: Proximity coupled, triangular microstrip antenna, diamond shape, bandwidth, radiation pattern.

I.INTRODUCTION

Due to the many attractive features and desirable characteristics, the microstrip antennas have gained the most important candidate for the modern wireless communication systems as well as an ultimate solution for development of handheld mobile devices in both commercial industries and research academia [1]. The present era of wireless communication possess many desirable features such as light weight, wide bandwidth, low cost, direct integrability with microwave circuitry [2]. To meet these requirements, microstrip antenna is an essential element which offers an optimal solution for modern wireless communication. Among different shapes of radiating patches such as square, rectangular, circular, ellipse etc. the equilateral triangular radiating patch was found to exhibit good radiation characteristics, simple to design and compact in size when compared to other microstrip patch shapes [3].

In recent years, the microstrip antenna designers have proposed many techniques to improve the antenna parameters such as microstripline feeding approaches of aperture coupled feeding and proximity coupled feeding etc. To improve the impedance bandwidth, radiation characteristics, gain, multiband operation etc., slot loading techniques [4-7]. In [4], the 50Ω microstripline inset fed triangular microstrip antenna has been studied with reconfiguration of a chip resistor. The dual frequency equilateral triangular microstrip is etched on the FR4 dielectric substrate is proposed in [5], the proposed antenna also is designed for different substrate thicknesses and patch sizes to achieve the dual polarization. A double T shaped stub tuning triangular microstrip antenna with slot [6] has been studied for wideband operation. A small slot coupled with a shorting-pin or chip-resistor triangular patch antenna has been presented in [7] for broadband operation. This antenna also resonates at fixed operating frequency with size reduction characteristics. Moreover, the above methods are complicated. To overcome these difficulties, in this paper simple microstripline proximity coupled feeding technique is used to achieve the dual band operation with wide impedance bandwidth.

II. ANTENNA DESIGN CONSIDERATION

The proposed antenna is designed for the frequency of 3 GHz using the relations present in the literature for the design of equilateral triangular microstrip antenna. A low cost glass epoxy substrate material with substrate $S_1$and S_2 having thicknesses of 0.32 cm and with dielectric constant $\varepsilon r = 4.2$ is used to simulate the antenna.

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Fig. 1 shows the geometry of proximity-coupled equilateral triangular microstrip antenna (PCETMSA).The equilateral triangular radiating patch with length 'a' is etched on top surface of substrate S_1. The value of 'a' is obtained from the equation (1);

$$a = \frac{2C}{3 f_r \sqrt{\varepsilon_r}} \quad (1)$$

where, C is the velocity of light and f_r is the resonating frequency. The microstripline feed of length L_f and width W_f is etched on the top surface of substrate S_2. The substrate S_2 is placed below substrate S_1 such that the tip of the feedline and the centre of the radiating patch coincide one over the other. The bottom surface of the substrate S_2 acts as the ground plane. The dimensions of the ground plane Lg and Wg are calculated from equation;

$$Wg = Lg = 6h+a$$

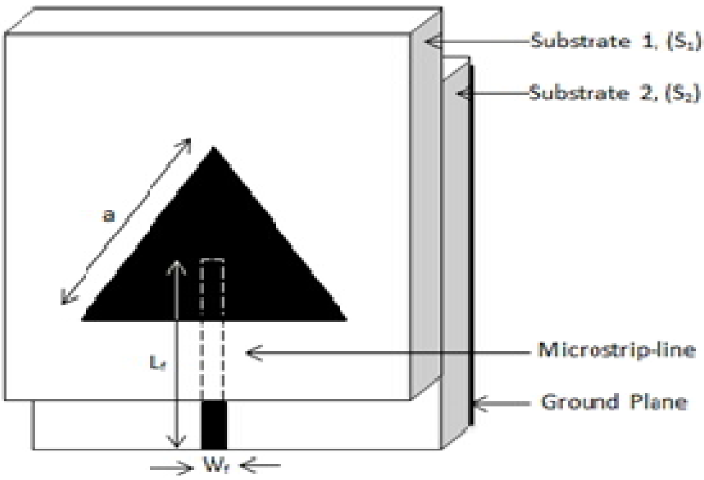

Fig. 1Top view Geometry of PCETMSA

Further, the study is carried out by loading diamond shape slot on the radiating patch as shown in Fig. 2 and Ansoft HFSS antenna module of DSPCETMSA is as shown in Fig. 3, where S_D is the distance of the diamond shape slot and S_L is the side length of the slot. All the dimensions of the PCETMSA and DSPCETMSA are shown in Table 1.

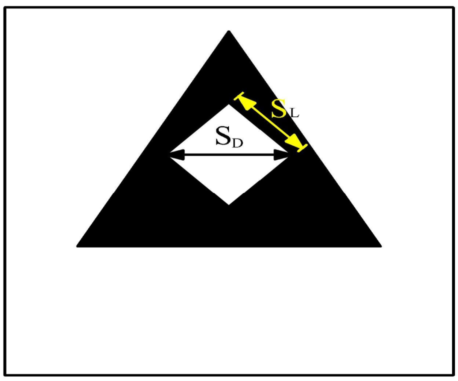

Fig. 2 Top view Geometry of DSPCETMSA

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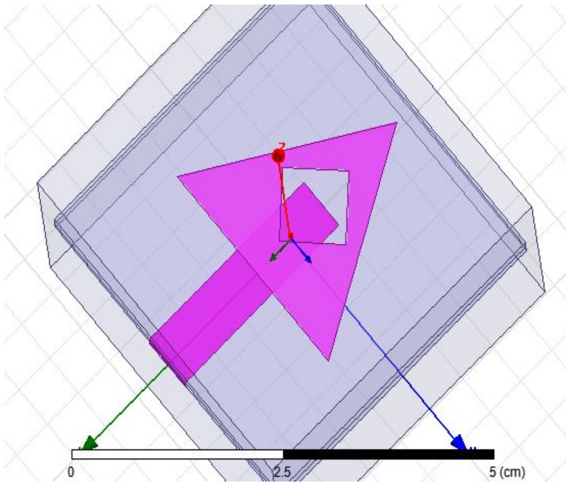

Fig. 3 Simulation antenna module of DSPCETMSA

Table 1: Designed parameters of the proposed antennas

Antenna Parameters	Dimensions in cm
Side length of equilateral triangle (a)	2.70
Length of the feedline L_f	2.5
Width of the feedlineW_f	0.633
Length and width of the ground plane (Lg and Wg)	4.6
Thickness of substrate S_1 and S_2 (h1+h2)	0.64
Length of the slot S_L	0.8
Distance of the slot S_D	1.13

III. SIMULATION RESULTS AND DISCUSSIONS

The proposed antennas are designed and simulated using Ansoft HFSS simulation software. The impedance bandwidth over return loss less than -10dB is calculated. The variations of return loss versus frequency of PCETMSA and DSPCETMSA are shown in Fig. 4 and 5. From these figures, the impedance bandwidth is calculated using the equation (2),

$$BW = \left[\frac{f2 - f1}{fc}\right] \times 100\ \% \qquad (2)$$

where, $f_1$and f_2 are the lower and upper cut-off frequencies of the operating bands respectively when its return loss reaches –10dB and f_C is the center frequency between $f_1$and f_2.

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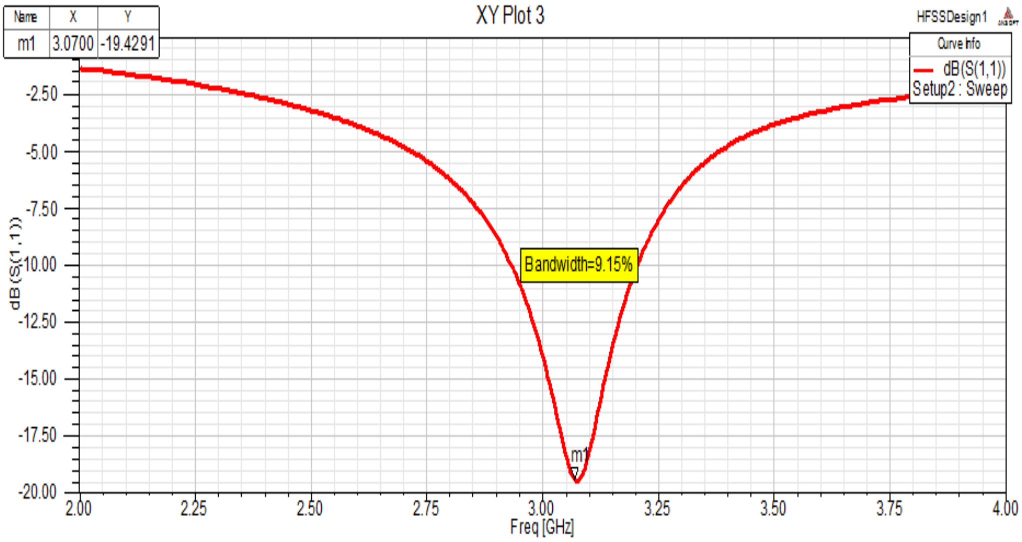

Fig.4. Simulation return loss versus frequency of PCETMSA

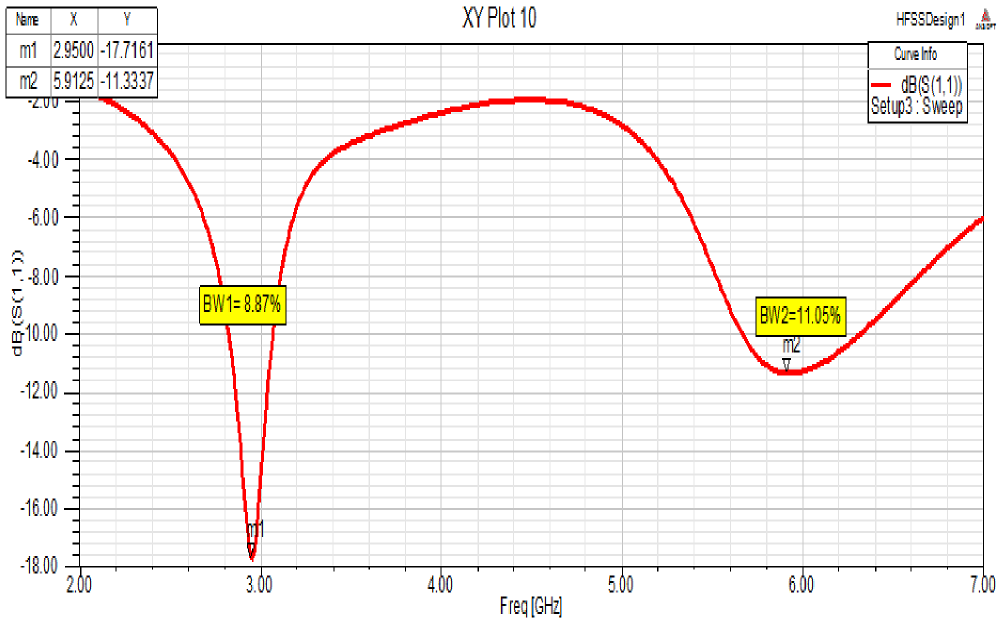

Fig.5. Simulation return loss versus frequency of DSPCETMSA

From the Fig. 4 and 5 it is observed that, the PCETMSA resonates at 3.07 GHz with impedance bandwidth of 9.15% and the minimum return loss is found to be -19.42dB, whereas after loading the diamond shape slot in the radiating patch by keeping all the parameters constant, the antenna resonates at two different frequency i.e., 2.95GHz and 5.91GHz with impedance bandwidth 8.87% and 11.05%, which is 1.90 times more when compared to the conventional microstrip antenna and the minimum return loss measured is found to be -17.71dB and -11.33dB respectively as shown in Fig. 5.

The E and H plane radiation patterns of the proposed antennas for φ at 0^0 and $90^0$and Ɵ at 0^0 and $90^0$is as shown in Fig. 6(a), Fig. 6(b) and Fig. 6(c). From these figures it is clear that, the obtained radiation patterns are broadside in nature.

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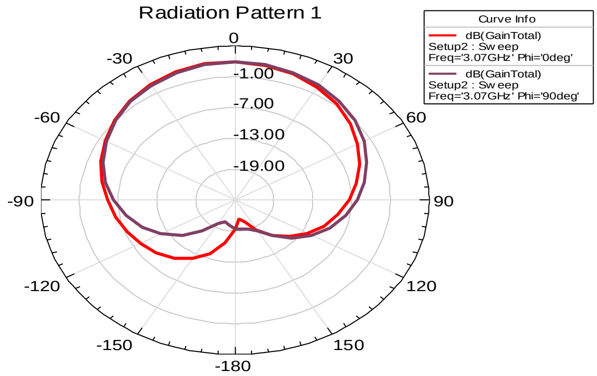
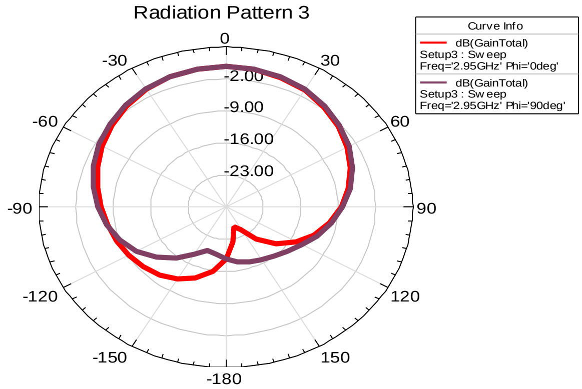
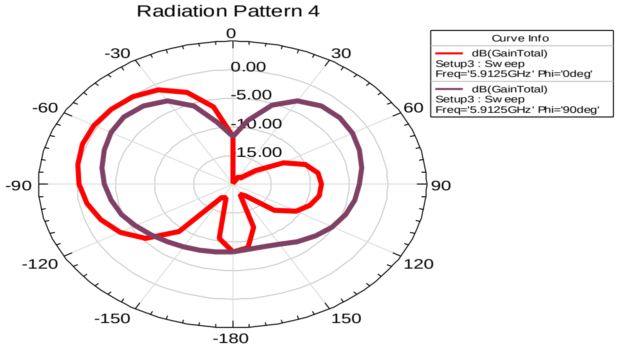


6(a)



6(b)



6(c)

Fig. 6.The typical radiation patterns of PCETMSA and DSPCETMSA measured at 6(a) 3.07 GHz, 6(b) 2.94 GHz and 6(c) 5.91GHz

V. CONCLUSIONS

From the detailed study, it is clear that the PCETMSA antenna gives a single frequency band but after loading the diamond shape slot i.e. DSPCETMSA resonates for two operating frequency bands with enhancement in the bandwidth with better broadside radiation pattern at the resonating frequencies. The antenna is also superior as it uses low cost substrate material and finds applications in modern communication systems such as WLAN, Bluetooth and Wi-Fi.

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